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MATERNAL INHERITANCE IN THE SOY BEAN

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THE soy bean, *Glycine hispida* Maxim., shows as different types two cotyledon colors, yellow and green. The beans with yellow cotyledons have two types of seed-coat colors, namely, green and yellow, while the beans with green cotyledons have always green seed-coats.¹ The inheritance of these types of cotyledons and of seed-coats has been proved by the author's experiments to be maternal. A brief notice of the experiments will be given in the following.

The green and yellow colors of cotyledons and seed-coats are obviously attributed to chlorophyll, which, on the ripening of the beans, is either changed from green into yellow or remains green. Further, according to the author's observations, the chlorophyll in the vegetative parts of the plant shows the same behavior as the chlorophyll of the cotyledons; in other words, the leaves and stems of the varieties with yellow cotyledons turn to a yellow color when they are gradually dying coincident with the ripening of the beans, while those of the varieties with green cotyledons remain green sometime after the dying of the whole plant. These facts suggest that the two types of cotyledon colors may represent two kinds of chlorophyll, one which changes into yellow under certain physiological conditions and one which is not so affected. The chlorophyll of the seed-coats, however, seems to behave somewhat differently from the chlorophyll in all

¹ Black and brown pigments also appear in the seed-coats of certain varieties. These pigments are entirely independent of the green and yellow colors here referred to in their inheritance, but they make the latter colors invisible or at least indistinct. By proper crosses, however, one can test whether a seed-coat covered by the black or brown pigment belongs to the green or the yellow category.

TABLE I
SOY BEAN CROSSES MADE IN STUDYING THE INHERITANCE OF GREEN AND YELLOW COLORS OF COTYLEDONS AND OF SEED-COATS

	Crossing No. I		Crossing No. II		Crossing No. III		Crossing No. IV		Crossing No. V		Crossing No. VI	
	Cotyle- dons	Seed- coat	Cotyle- dons	Seed- coat	Cotyle- dons	Seed-coat	Cotyle- dons	Seed- coat	Cotyle- dons	Seed-coat	Cotyle- dons	Seed-coat
Parents												
Female....	green	green	green	green	yellow	green	yellow	green	yellow	green	yellow	green
Male.....	yellow	yellow	yellow	green	green	green	green	green	green	yellow	yellow	yellow
F ₁ -Ind.....	green	green	green	green	yellow	green	yellow	green	yellow	green	yellow	green
No. Ind....	24	24	3	3	40	40	4	4	9	5	5	5
F ₂ -Ind.....	green	green	green	green	green	yellow	yellow	green	yellow	green	yellow	green
No. Ind....	3,129	1,248	322	216	11,836	825 : 288 (74.1% : 25.9%)	846	436	1,815	418 : 128 (76.6% : 23.4%)	169	56 : 19 (74.7% : 25.3%)
F ₃ -Fam.....	green- constant		green- constant		yellow- constant		yellow- constant		yellow- constant		yellow- constant	
No. Fam...	1,248		216		1,113		436		546		74	
No. Ind....	72,501		16,498		28,231		2,341		55,354		4,635	

other parts of the plant, since, as was already noted, yellow cotyledons are accompanied by green seed-coats in certain varieties.

The crossing experiments which have been made by the author since 1910 with these different types of beans have produced the results shown in Table I, the main facts being summarized as follows.

I. The F_1 cotyledons of the crosses reciprocal to each other are of the same character as the female parents. In respect to the cotyledon colors, the F_2 and following generations show the characters of the F_1 generation exclusively, instead of a Mendelian segregation between the yellow and green colors. Hence we are probably dealing with characters which can be inherited only through the female parents.

II. The inheritance of the seed-coat colors is a more complicated phenomenon. In the cross "green cotyledons, green seed-coat" (♀) \times "yellow cotyledons, yellow seed-coat" (♂), the green seed-coat is inherited through the female parent exclusively, just as in the case of the cotyledon colors; but in the reciprocal cross the green and yellow seed-coats show Mendelian segregation, the former being dominant.

The maternal inheritance observed above was not due to self-fertilization succeeding failures in artificial crossing, because several other characters showed inheritance through the male parents.

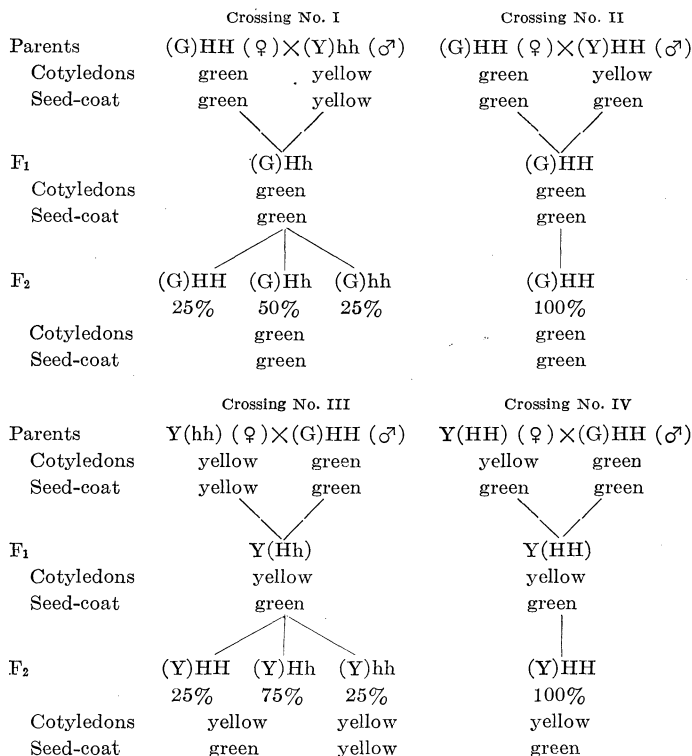
An interpretation of the inheritance phenomena under consideration is suggested as follows. In the first place, let us refer again to the two different kinds of chlorophyll assumed to be concerned in producing the green and yellow cotyledons; namely, the chlorophyll which can be changed into yellow and the chlorophyll which remains green. (These will be denoted respectively as "(Y)" and "(G)" in the later descriptions.) These characteristics of chlorophyll may be due to heritable traits of the chromatophores or of the cytoplasm, and not to hereditary elements in the nucleus. As, on the fertilization of

the egg-cell, the chromatophores and the cytoplasm of the female gamete will probably remain as such without being supplemented by those from the male gamete, their characteristics would naturally be inherited only through the female parent. In the second place we may assume that a pair of Mendelian factors is concerned in the inheritance of the colors of the seed-coats. The factor "H" inhibits the chlorophyll "(Y)" in the seed-coat of the beans with yellow cotyledons from changing to yellow, producing beans with yellow cotyledons and green seed-coat; the absence of the factor "H," expressed by "h," allows the seed-coat of the bean with yellow cotyledons to remain yellow. The seed-coat of the bean with green cotyledons remains green no matter whether the factor "H" is present or absent, because the beans of this kind have the chlorophyll "(G)" which is incapable of changing the color.

The justice of the contention regarding the bean with green cotyledons, moreover, is supported by the following observations. The F_2 families of the crosses "green cotyledons, green seed-coat" (♀) \times "yellow cotyledons, yellow seed-coat" (♂) were actually composed of two kinds of individuals which were distinguishable from each other by a slight difference of the intensity of green color in the seed-coats, and the numerical relation between these two kinds of individuals was approximately the Mendelian mono-hybridal segregation ratio, the darker seed-coat being dominant to the lighter one. Again, in the F_3 generation of these crosses, there were obtained three types of families, two which were uniformly of the darker and of the lighter seed-coats respectively and one which was a mixture of both. By comparing the green seed-coats of the female parents in these crosses with those of the progeny, the former was found to belong to the darker class mentioned above. These variations in the green color of the seed-coats may be regarded as being due to the influence of the Mendelian factors "H" and "h" respectively on the chlorophyll "(G)"; from which it follows

that the method of inheritance in the beans with yellow cotyledons obtains also in the beans with green cotyledons.

Keeping these statements in mind the cases in Table I may be illustrated as follows:



If the foregoing interpretation really represents the facts in this investigation, we may consider also crosses in which forms such as $(G)Hh$, $(G)hh$, and $(Y)Hh$ were used as the parents, since in these crossings phenomena different from those in Table I would be expected. These expectations have been fulfilled in further experiments in which individuals from the previous experiments representing different intensities of seed-coat color were used as the parent plants. The results of these crosses, accompanied by interpretations, are shown in Table II.

TABLE II

CROSSES MADE AMONG THE PROGENY OF THE HYBRIDS SHOWN IN TABLE I

		Parents		F ₁		F ₂	
		Female	Male	Character	No. of Individuals	Character	No. of Individuals
Crossing No. VII.....	Cotyledons	yellow	green	yellow	22	yellow	2,381
	Seed-coat	yellow	green	yellow	22		
	Interpret.	(Y) hh	(G) hh	(Y) hh	100%		
Crossing No. VIII.....	Cotyledons	yellow	green	yellow	18	yellow	1,963
	Seed-coat	green	green	{ green	10		
				{ yellow	8		
	Interpret.	(Y) Hh	(G) hh	{ (Y) Hh	50%		
				{ (Y) hh	50%		
Crossing No. IX.....	Cotyledons	yellow	green	yellow	9	yellow	1,108
	Seed-coat	green	green	{ green	7		
				{ yellow	2		
	Interpret.	(Y) Hh	(G) Hh	{ (Y) HH	25%		
				{ (Y) Hh	50%		
				{ (Y) hh	25%		

The maternal inheritance described in this paper seems to be essentially the same phenomenon as the inheritance of the character "*albo-maculata*" which was studied by Correns² in *Mirabilis Jalapa* and also by Baur³ in *Antirrhinum majus*. In each case one is dealing with chromathophore characters.

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² Correns, C., *Zeitschr. f. ind. Abst. u. Vererbungslehre*, Bd. I, 1909, pp. 291-329; *Ibid.*, Bd. II, 1909, pp. 331-340.

³ Baur, E., *Zeitschr. f. ind. Abst. u. Vererbungslehre*, Bd. IV, 1910, pp. 81-102.